Chapter 4 Requirements Engineering

4.1 Functional and non-functional requirements

4.2 Requirements engineering processes

4.3 Requirements Elicitation

4.4 Requirements specification

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Requirements Engineering

Definition and Importance of Requirements Engineering (RE)

- Requirements are descriptions of services and constraints that a system should adhere to.
- The process of identifying, analyzing, documenting, and validating these is called Requirements Engineering.

Variability in Requirement Definitions

- Requirements can range from high-level abstract statements to detailed, formal definitions.
- Different documents may serve as the "requirements document" depending on the phase of the project.

Types of Requirements

1. **User Requirements**: High-level, often in natural language, describing what the system is expected to provide.
2. **System Requirements**: Detailed descriptions of the system’s functions, services, and constraints.

Audience for Requirements

- User requirements are generally for managers and others not concerned with implementation.
- System requirements are for those involved in system implementation and support.

System Stakeholders

Examples include:

1. Patients and relatives
2. Doctors
3. Nurses
4. Medical receptionists
5. IT staff
6. Medical ethics manager
7. Health care managers
8. Medical records staff

Phases in RE

- Early-stage RE can lead to a feasibility study assessing the system's technical and financial viability.
- A traditional RE phase typically precedes system implementation, resulting in a requirements document.

Agile vs. Traditional RE

- In agile processes, requirements may be concurrently elicited as the system is developed.
- For many large systems, a separate RE phase is still common.
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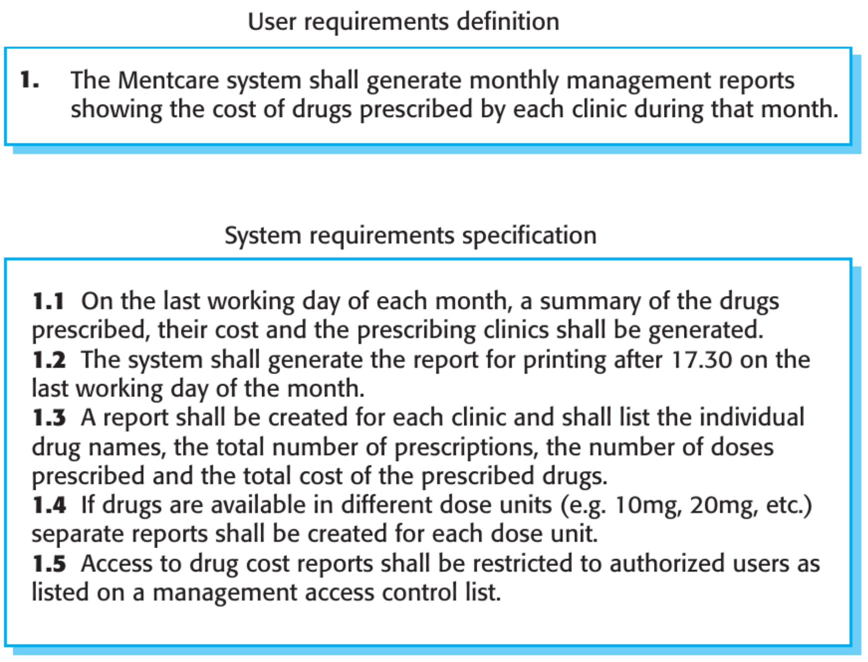

User requirements definition

1. The Mentcare system shall generate monthly management reports showing the cost of drugs prescribed by each clinic during that month.

System requirements specification

1.1 On the last working day of each month, a summary of the drugs prescribed, their cost and the prescribing clinics shall be generated.
1.2 The system shall generate the report for printing after 17.30 on the last working day of the month.
1.3 A report shall be created for each clinic and shall list the individual drug names, the total number of prescriptions, the number of doses prescribed and the total cost of the prescribed drugs.
1.4 If drugs are available in different dose units (e.g. 10mg, 20mg, etc.) separate reports shall be created for each dose unit.
1.5 Access to drug cost reports shall be restricted to authorized users as listed on a management access control list.

Figure 4.1 User and system requirements

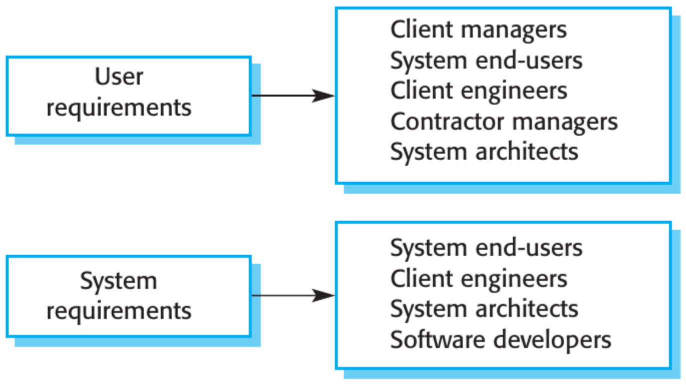


Figure 4.2 Readers of different types of requirements specification

4.1 Functional and non-functional requirements

Types of Software System Requirements

1. **Functional Requirements**: Statements detailing what services the system should provide, how it should respond to inputs, and its behavior under specific conditions.
    - May also state what the system should not do.
2. **Non-Functional Requirements**: Constraints on the services or functions, including timing, development process, and standards.
    - Generally apply to the system as a whole, not to individual features.

Ambiguity and Interdependence in Requirements

- The distinction between functional and non-functional requirements is not always clear-cut.
- One requirement often generates or constrains other requirements.

Overall System Requirements

- System requirements specify not just the services or features but also the necessary functionality to ensure effective delivery.

4.1.1 Functional requirements

Definition and Levels of Functional Requirements

1. **User-Level Functional Requirements**: Written in natural language for system users and managers to understand.
2. **System-Level Functional Requirements**: Detailed descriptions for developers, specifying system functions, inputs, outputs, and exceptions.
3. **Variability in Detail**: Requirements can range from general to very specific, depending on organizational needs and existing systems.

Off-the-Shelf Software and Information Requirements

- In cases where off-the-shelf software suffices, the focus shifts from functional specifications to information requirements.
- Information requirements specify needed data, its organization, and delivery method.

Imprecision and Its Consequences

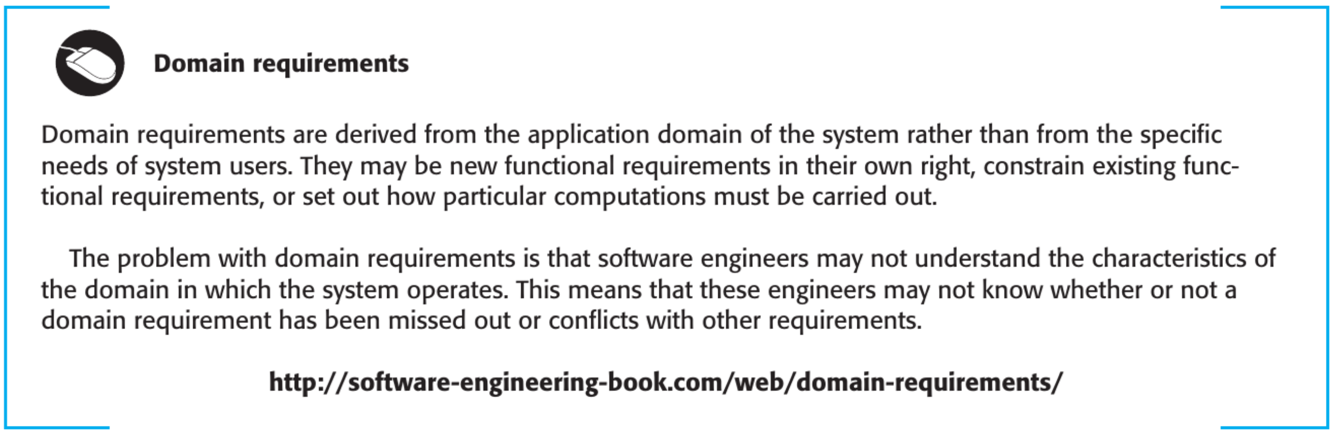
- Ambiguous requirements can lead to misunderstandings between customers and developers, causing delays and increased costs.

Ideal Characteristics of Functional Requirements

1. **Completeness**: All services and information required by the user should be defined.
2. **Consistency**: Requirements should not be contradictory.

Practical Limitations

- Achieving completeness and consistency is often only possible for very small systems.
- Large systems have multiple stakeholders with varying, and often inconsistent, needs.
- Mistakes and omissions are common in specifications for large, complex systems.
- Inconsistencies may only become apparent after deeper analysis or during development.



Domain requirements

Domain requirements are derived from the application domain of the system rather than from the specific needs of system users. They may be new functional requirements in their own right, constrain existing functional requirements, or set out how particular computations must be carried out.

The problem with domain requirements is that software engineers may not understand the characteristics of the domain in which the system operates. This means that these engineers may not know whether or not a domain requirement has been missed out or conflicts with other requirements.

http://software-engineering-book.com/web/domain-requirements/

4.1.2 Non-functional requirements

Key Points Summary

Definition of Non-Functional Requirements

- Non-functional requirements are not directly related to specific services but specify or constrain system characteristics such as reliability, response time, and memory use.

Importance and Critical Nature

- Often more critical than functional requirements, as failure to meet them can make the whole system unusable.

Implementation Challenges

1. **Architectural Impact**: Non-functional requirements may affect the overall system architecture.
2. **Related Functional Requirements**: A single non-functional requirement might generate multiple related functional requirements and constraints.

Sources of Non-Functional Requirements

1. **Product Requirements**: Specify runtime behavior such as performance, reliability, and usability.
2. **Organizational Requirements**: Derive from customer and developer policies, specifying operational and development process constraints.
3. **External Requirements**: Imposed by external factors like regulations, legislation, or ethical considerations.

Problems with Non-Functional Requirements

- Often stated as general goals, leaving scope for interpretation and disputes.
- Difficult to translate into measurable requirements.

Quantitative Specification

- Whenever possible, non-functional requirements should be stated quantitatively for objective testing.

Conflicts and Interactions

- Non-functional requirements often conflict or interact with other functional or non-functional requirements, complicating implementation.

Documentation Challenges

- Difficult to separate functional and non-functional requirements in documentation while maintaining clarity on their interrelationships.

Importance in Critical Systems

- Reliability, safety, and confidentiality are especially important for systems where failure could have severe consequences.

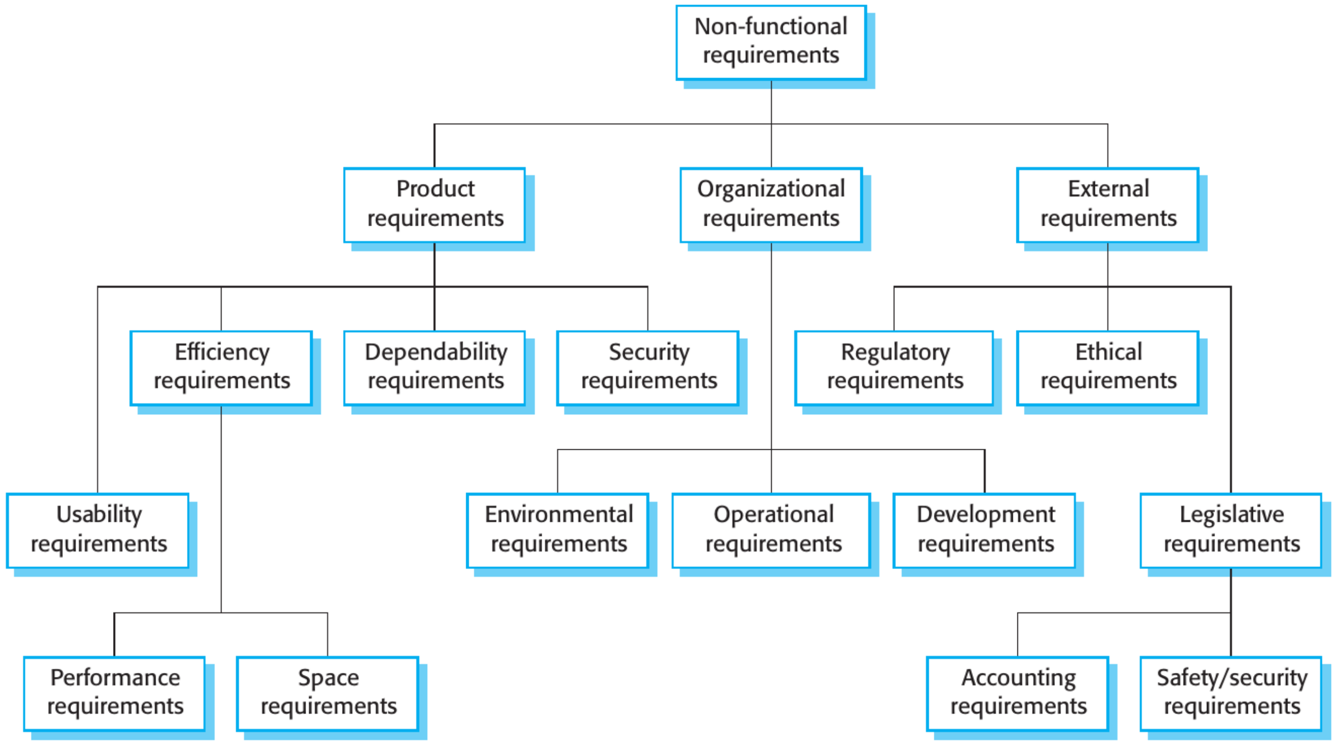


Figure 4.3 Types of non-functional requirements

2. An individual non-functional requirement, such as a security requirement, may generate several, related functional requirements that define new system ser-

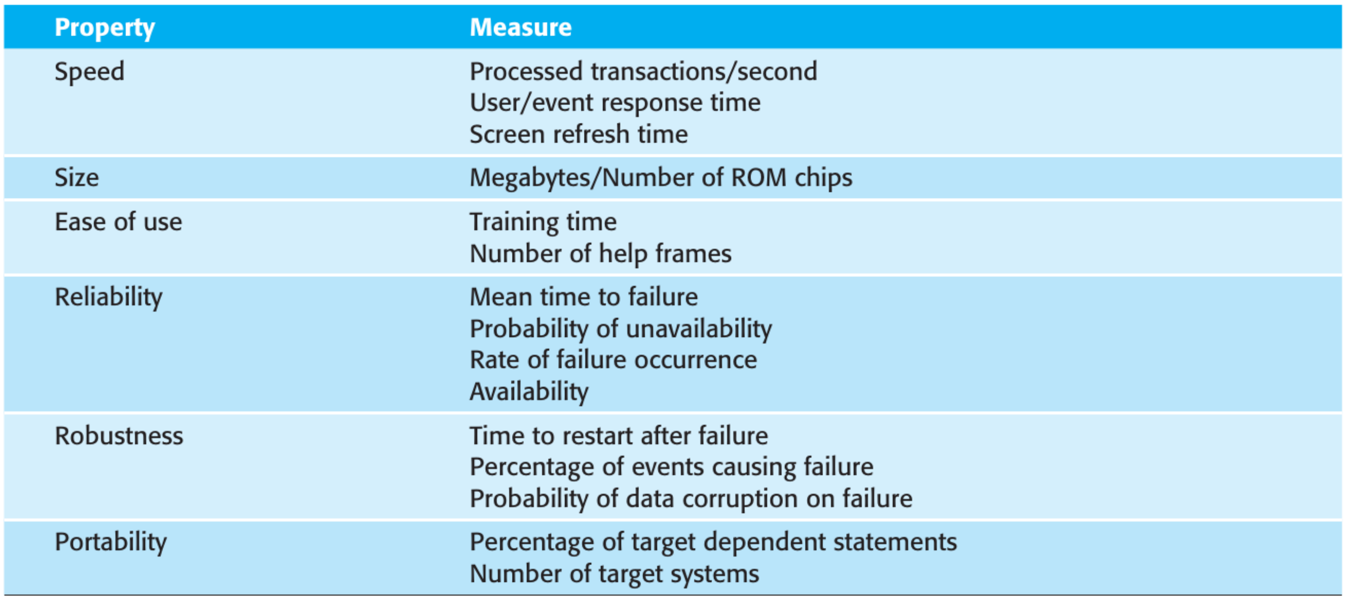
PRODUCT REQUIREMENT
The Mentcare system shall be available to all clinics during normal working hours (Mon–Fri, 08:30–17:30). Downtime within normal working hours shall not exceed 5 seconds in any one day.

ORGANIZATIONAL REQUIREMENT
Users of the Mentcare system shall identify themselves using their health authority identity card.

EXTERNAL REQUIREMENT
The system shall implement patient privacy provisions as set out in HStan-03-2006-priv.

Figure 4.4 Examples of possible non-functional requirements for the Mentcare system

programming language; the development environment or process standards to be used; and environmental requirements that specify the operating environment of the system.



Property	Measure
Speed	Processed transactions/second User/event response time Screen refresh time
Size	Megabytes/Number of ROM chips
Ease of use	Training time Number of help frames
Reliability	Mean time to failure Probability of unavailability Rate of failure occurrence Availability
Robustness	Time to restart after failure Percentage of events causing failure Probability of data corruption on failure
Portability	Percentage of target dependent statements Number of target systems

Figure 4.5 Metrics for specifying non-functional requirements

I have rewritten this to show how the goal could be expressed as a "testable" non-

4.2 Requirements engineering processes

Core Activities in Requirements Engineering (RE)

1. **Elicitation and Analysis**: Discovering requirements by interacting with stakeholders.
2. **Specification**: Converting discovered requirements into a standard form.
3. **Validation**: Ensuring the requirements define the system that the customer wants.

Iterative Nature of RE

- RE is an iterative process where activities are interleaved.
- The output is a system requirements document.

Effort Allocation in the Spiral Model

- Early stages focus on high-level business and non-functional requirements.
- Later stages focus on detailed non-functional and system requirements.

Flexibility in the Spiral Model

- The number of iterations can vary.
- Agile development can be used to develop requirements and implementation concurrently.

Requirements Change Management

- Requirements often change due to better understanding, organizational shifts, or system modifications.
- Changes must be managed to understand their impact on other requirements and the overall system.

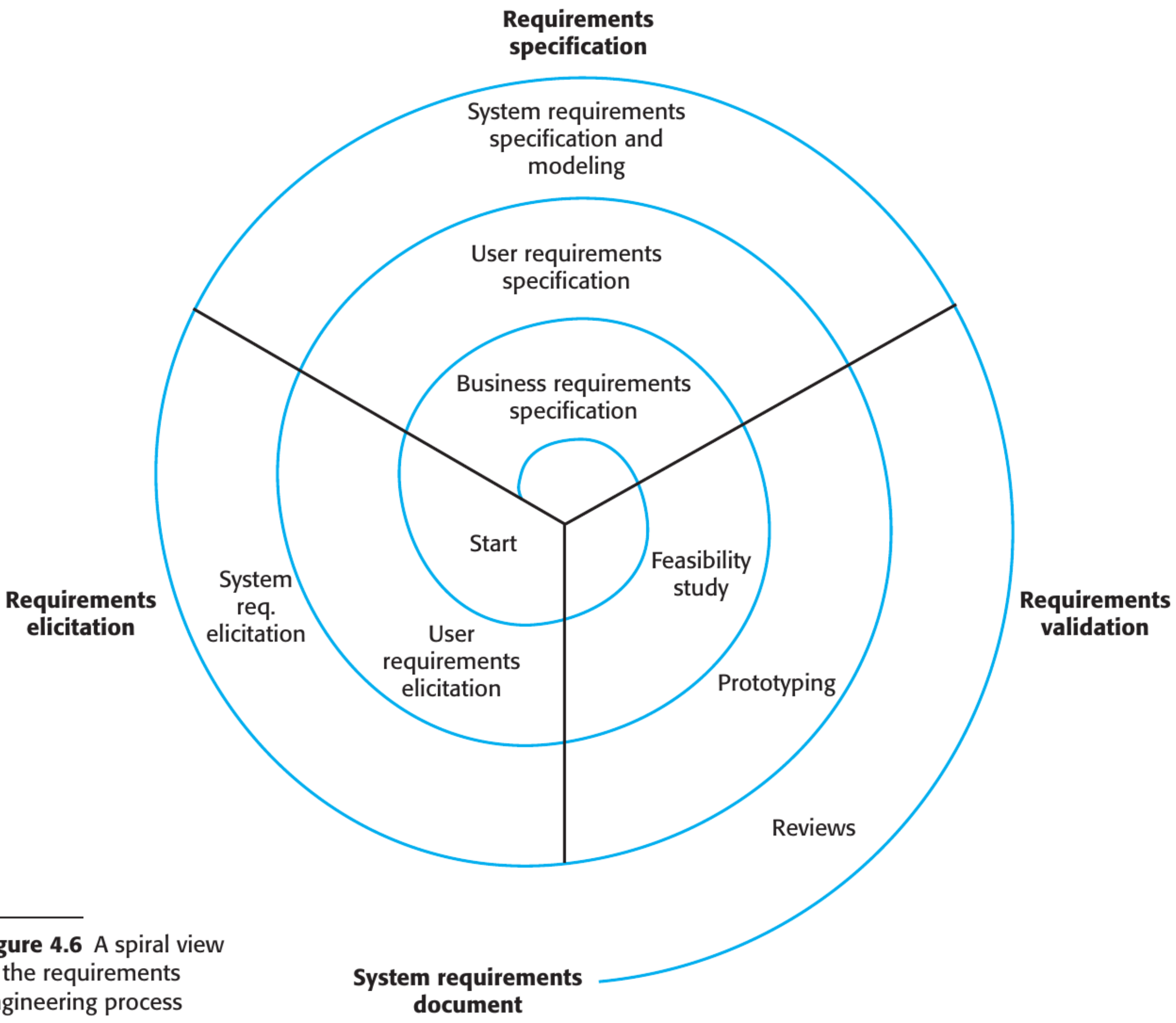

Requirements specification
System requirements specification and modeling
User requirements specification
Business requirements specification
Start
Feasibility study
Prototyping
Reviews
Requirements validation
Requirements elicitation
System req. elicitation
User requirements elicitation
System requirements document

Figure 4.6 A spiral view of the requirements engineering process

4.3 Requirements Elicitation

Aims of Requirements Elicitation

- To understand stakeholders' work and how a new system could support it.
- To gather information on the application domain, services, features, performance, hardware constraints, etc.

Challenges in Requirements Elicitation

1. **Unclear Expectations**: Stakeholders often have general or unrealistic expectations.
2. **Domain-Specific Language**: Stakeholders may express requirements in terms specific to their domain, which engineers might not understand.
3. **Diverse Stakeholders**: Different stakeholders may express conflicting requirements.
4. **Political Factors**: Internal politics may influence system requirements.
5. **Dynamic Environment**: Economic and business conditions may change, affecting requirements priorities.

Process Activities

1. **Requirements Discovery and Understanding**: Interact with stakeholders to discover their requirements.
2. **Requirements Classification and Organization**: Group and organize the unstructured collection of requirements.
3. **Requirements Prioritization and Negotiation**: Resolve conflicting requirements through prioritization and negotiation.
4. **Requirements Documentation**: Document the requirements for the next iteration or for the final requirements document.

Iterative Nature of the Process

- Elicitation and analysis is an iterative process with continual feedback.
- The process cycle starts with discovery and ends with documentation.

Stakeholder Engagement

- Regular stakeholder meetings are crucial for resolving conflicts and achieving compromises.

Requirements Documentation

- Use simple language and diagrams.
- Use shared documents or wikis for better stakeholder engagement.

4.3.1 Requirements Elicitation Techniques

Fundamental Approaches to Requirements Elicitation

1. **Interviewing**: Talking to people about what they do.
2. **Observation or Ethnography**: Watching people do their job to understand their tasks and tools.

Interviewing

- **Types of Interviews**:
    i. **Closed Interviews**: Predefined set of questions for stakeholders.
    ii. **Open Interviews**: No predefined agenda, more exploratory.
- **Challenges in Interviewing**:
    i. **Domain Jargon**: Stakeholders use domain-specific terminology that may be misunderstood.
    ii. **Implicit Knowledge**: Stakeholders may omit mentioning basic domain knowledge, assuming it's understood.
- **Effectiveness**:
    - Good for general understanding but not for specific, detailed requirements.
    - Not effective for organizational constraints due to subtle power dynamics.
- **Best Practices**:
    i. Be open-minded and willing to listen.
    ii. Use springboard questions or prototypes to prompt discussions.

Ethnography

- **Importance**: Helps understand social and organizational factors that impact practical system operation.

- **Benefits**:
  i. Discovers implicit system requirements.
  ii. Observes actual tasks and work relationships.
- **Types of Requirements Derived**:
  i. Requirements based on how people actually work.
  ii. Requirements based on cooperation and awareness among workers.
- **Limitations**:
  - Not effective for broader organizational or domain requirements.
  - May not aid in innovation.

Combining Techniques

- Information from interviews is often combined with ethnography and other sources.
- Both interviewing and ethnography have limitations and should be used in conjunction with other techniques.

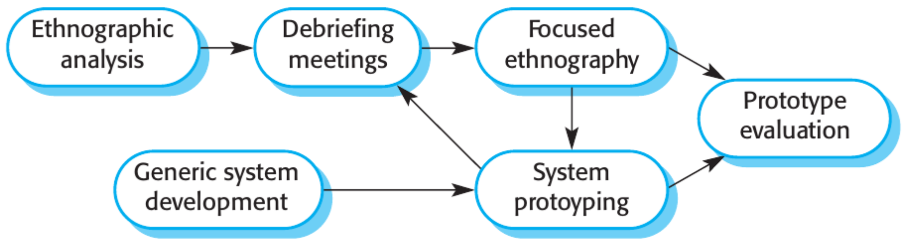


Figure 4.8 Ethnography and prototyping for requirements analysis

4.3.2 Stories and Scenarios

Stories and Scenarios: An Introduction

- Both stories and scenarios capture real-life examples to describe how a system can be used for specific tasks.
- Stories provide high-level, narrative text descriptions for system use.
- Scenarios are structured and provide specific details like inputs and outputs.

Differences Between Stories and Scenarios

1. **Structure**: Stories are less structured than scenarios.
2. **Detail Level**: Stories provide a high-level overview, while scenarios delve into specifics.
3. **Purpose**: Stories are effective for setting out the "big picture," whereas scenarios are used for more specific user interactions.

Advantages of Using Stories

- Easily relatable and understood by stakeholders.
- Facilitates discussion and acts as a starting point for eliciting requirements.
- Useful for gathering information from a broader community by sharing them on platforms like wikis.

Developing Scenarios from Stories

- High-level stories can be broken down into more specific scenarios.
- Scenarios provide detailed descriptions of user interaction sessions.

Components of a Scenario

1. **Initial Expectations**: What the system and users expect when the scenario starts.
2. **Normal Flow of Events**: The usual sequence of actions in the scenario.
3. **Exception Handling**: What can go wrong and how the resulting problems are handled.
4. **Concurrent Activities**: Other activities that might be happening simultaneously.
5. **Ending State**: The system state when the scenario concludes.

Use in Agile Methods

- In agile methods like Extreme Programming, "user stories" are more like narrative scenarios designed to help elicit requirements.

Facilitation with Stakeholders

- Both stories and scenarios can be used to engage stakeholders in discussions, especially when there are different ways to achieve the same result.

By using stories and scenarios, you can capture both the high-level view and the detailed requirements, thereby providing a comprehensive understanding of what the system is expected to do.

4.4 Requirements specification

Requirements Specification: An Overview

- The process involves writing down both user and system requirements.
- The ideal attributes for these requirements are clarity, unambiguity, easy comprehension, completeness, and consistency.
- In reality, these attributes are hard to achieve due to different interpretations and inherent conflicts among stakeholders.

User Requirements

1. **Language**: Primarily written in natural language, supported by diagrams and tables.
2. **Scope**: Should focus on the external behavior of the system, not on how it is designed or implemented.
3. **Audience**: Intended to be understandable by users without detailed technical knowledge.
4. **Notation**: Should avoid software jargon and formal notations.

System Requirements

- These are expanded versions of user requirements and serve as the base for system design.
- Should be complete and detailed specifications of the whole system.
- While ideally focusing on external behavior and operational constraints, they may include some design details for practical reasons.

Reasons for Including Design Details in System Requirements

1. **Initial Architecture**: Helps to structure the requirements specification. For example, the requirements for the iLearn system were organized based on an initial architecture.
2. **Interoperability**: New systems often have to work with existing systems, imposing certain design constraints.
3. **Non-Functional Requirements**: Specific architectures might be necessary to satisfy non-functional requirements like reliability.

By adhering to these guidelines and considerations, the requirements specification will serve as a strong foundation for the subsequent phases of the software development process.

4.4.1 Natural language specification

Natural Language Specification: Overview

- Natural language is expressive, intuitive, but potentially vague and ambiguous.
- Despite alternatives, it remains the most widely used way of specifying system and software requirements.

Guidelines for Writing Requirements in Natural Language

1. **Standard Format**: Create a standard format and make sure all requirements adhere to it. Ideally, use one or two sentences of natural language for each requirement.
2. **Consistency in Language**: Distinguish between mandatory ("shall") and desirable ("should") requirements for clarity.
3. **Text Highlighting**: Use bold, italic, or color to emphasize key parts of the requirement.
4. **Avoid Technical Jargon**: Do not assume that all readers understand software engineering terms. Avoid jargon, abbreviations, and acronyms.
5. **Requirement Rationale**: Include a rationale for each user requirement, specifying why it was included and who proposed it. This helps in future consultation or changes.

By adhering to these guidelines, you can make the natural language specifications clearer, more consistent, and easier to understand. This can be particularly helpful in minimizing misunderstandings among stakeholders.

4.4.2 Structured specifications

Structured Specifications: Overview

- Structured natural language aims for uniformity while retaining the expressiveness and understandability of natural language.
- Standard templates or structured forms are used to specify requirements.

Features of Structured Specifications

- May use programming constructs for alternatives and iteration.
- Key elements can be highlighted using shading or different fonts.

Card-Based Approach (VOLERE)

- User requirements are initially written on cards, one per card.
- Fields on the card may include rationale, dependencies, source, and supporting materials.

Structured Specification Components

1. **Function/Entity Description**: Briefly describes the function or entity being specified.
2. **Inputs**: Describes the inputs and their origins.
3. **Outputs**: Describes the outputs and their destinations.
4. **Requirements**: Information about other entities required for computation.
5. **Action Description**: Description of the action to be taken.
6. **Preconditions and Postconditions**: Conditions before and after the function is called.
7. **Side Effects**: Description of any side effects of the operation.

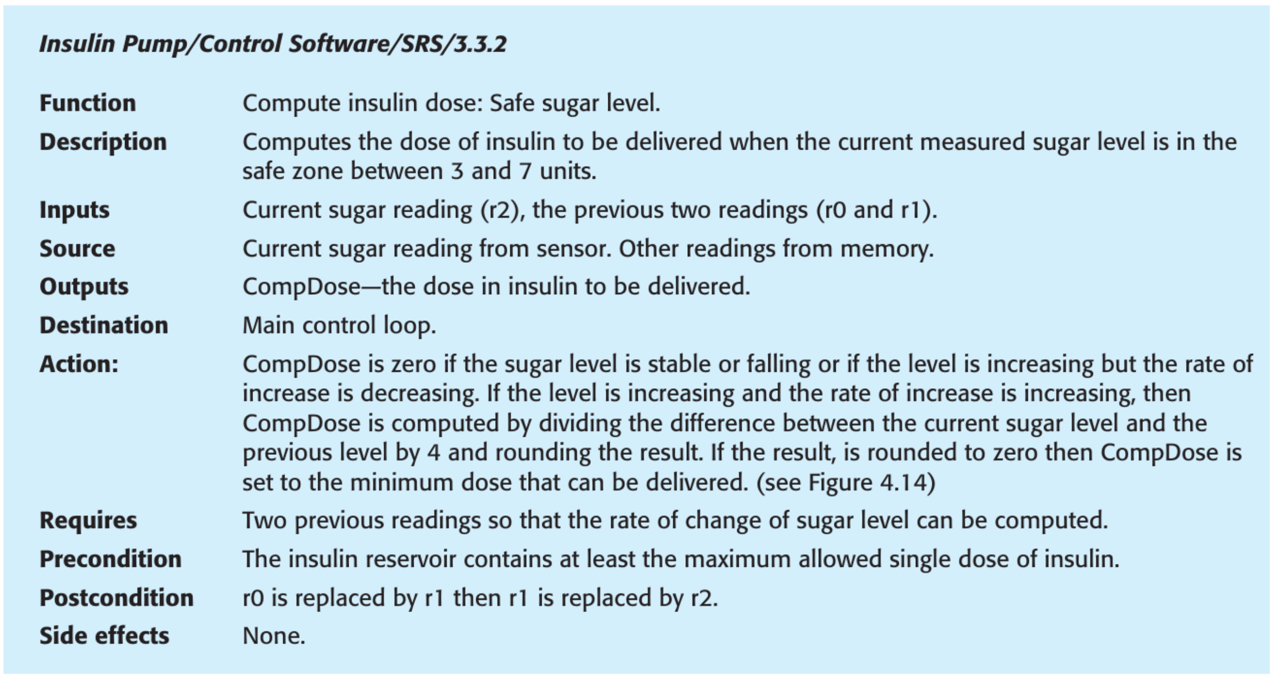
Advantages and Challenges

- Addresses some problems of natural language by reducing variability and improving organization.
- Still can be difficult to specify complex computations clearly.

Extending Natural Language Specifications

- Tables or graphical models can be used to add extra information.
- Especially useful for alternative situations or complex computations (e.g., calculating insulin doses based on rate of blood sugar change).

By utilizing structured specifications, you can balance the natural language's flexibility with the precision needed for complex requirements, providing a more consistent and organized approach.



Insulin Pump/Control Software/SRS/3.3.2

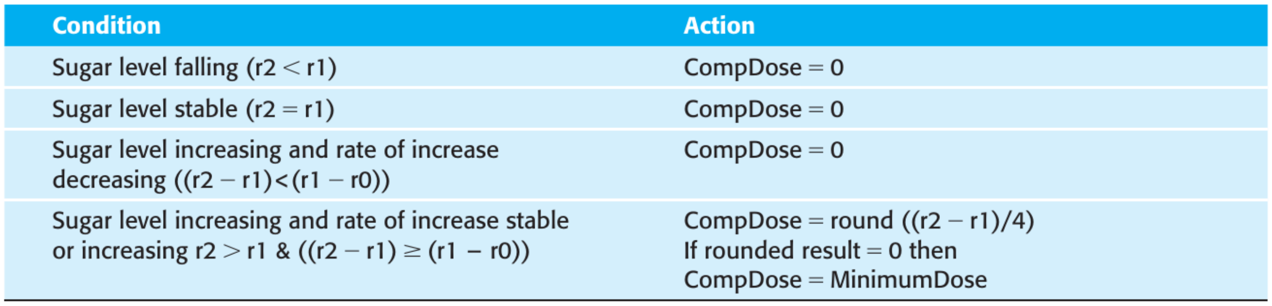
Function	Compute insulin dose: Safe sugar level.
Description	Computes the dose of insulin to be delivered when the current measured sugar level is in the safe zone between 3 and 7 units.
Inputs	Current sugar reading (r2), the previous two readings (r0 and r1).
Source	Current sugar reading from sensor. Other readings from memory.
Outputs	CompDose—the dose in insulin to be delivered.
Destination	Main control loop.
Action:	CompDose is zero if the sugar level is stable or falling or if the level is increasing but the rate of increase is decreasing. If the level is increasing and the rate of increase is increasing, then CompDose is computed by dividing the difference between the current sugar level and the previous level by 4 and rounding the result. If the result, is rounded to zero then CompDose is set to the minimum dose that can be delivered. (see Figure 4.14)
Requires	Two previous readings so that the rate of change of sugar level can be computed.
Precondition	The insulin reservoir contains at least the maximum allowed single dose of insulin.
Postcondition	r0 is replaced by r1 then r1 is replaced by r2.
Side effects	None.

Figure 4.13 The structured specification of a requirement for an insulin pump

more effectively. However, it is still sometimes difficult to write requirements in a clear and unambiguous way, particularly when complex computations (e.g., how to

Figure 4.14 The tabular specification of computation in an insulin pump

ous readings. Figure 4.14 is a tabular description of how the rate of change of blood sugar is used to calculate the amount of insulin to be delivered.



Condition	Action
Sugar level falling (r2 < r1)	CompDose = 0
Sugar level stable (r2 = r1)	CompDose = 0
Sugar level increasing and rate of increase decreasing ((r2 − r1)<(r1 − r0))	CompDose = 0

Sugar level increasing and rate of increase stable or increasing r2 > r1 & ((r2 − r1) ≥ (r1 − r0))	CompDose = round ((r2 − r1)/4)
	If rounded result = 0 then
	CompDose = MinimumDose

4.4.3 Use cases

Use Cases: Overview

- Use cases describe interactions between users and a system via graphical models and structured text.
- They originated from the Objectory method and are now a fundamental part of Unified Modeling Language (UML).

Components of Use Cases

1. **Actors**: Represented as stick figures, these can be human users or other systems.
2. **Type of Interaction**: Represented as a named ellipse, each class of interaction is distinct.

3. **Linking Lines**: Lines connect actors with the interaction. Optionally, arrowheads may indicate who initiates the interaction.

Documentation

- Use cases are documented using high-level use case diagrams.
- Each use case should have a textual description that can be further elaborated using other UML models.

Application & Limitations

- Use cases are commonly used in object-oriented modeling.
- They are considered by some as too fine-grained for initial requirements elicitation and are often more useful in system design.

Interpretation of Use Cases

- Some consider each use case as a single, low-level interaction scenario.
- Others, like Stevens and Pooley, argue that a use case can include a set of related, low-level scenarios.
  - This set would include a normal interaction scenario plus scenarios for each possible exception.

In summary, use cases offer a structured way to document system-user interactions but may be too detailed for early stages of requirements engineering. They can be adapted to represent either single interactions or sets of related interactions.

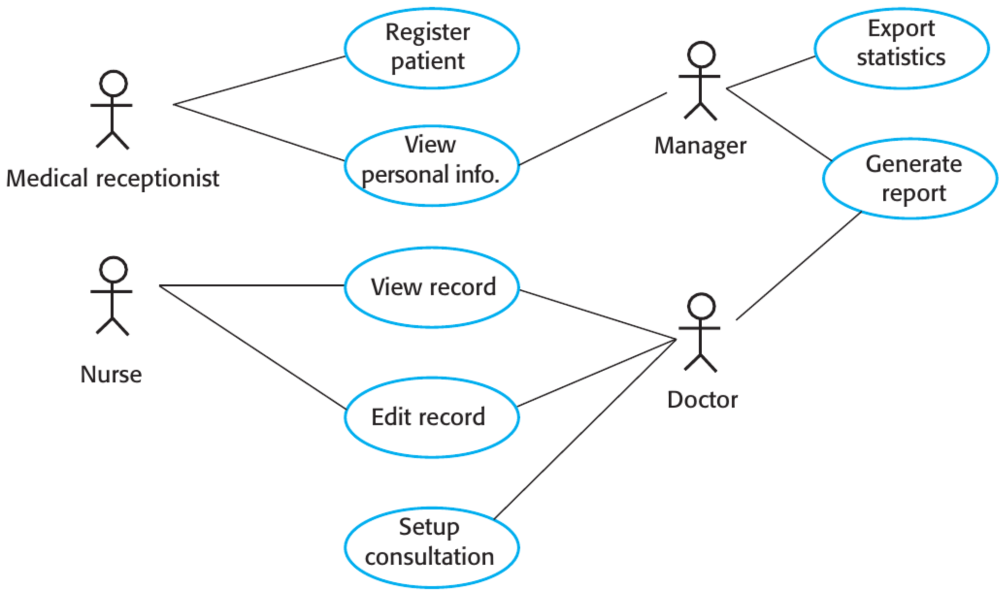


Figure 4.15 Use cases for the Mentcare system

4.4.4 The software requirements document

The Software Requirements Document (SRS)

- Serves as an official statement specifying what developers should implement.
- May include both user and system requirements.

- Essential for outsourced systems, complex multi-team developments, and where detailed analysis is mandatory.

Agile Methods vs Traditional Approaches

1. **Agile Methods**:

- Argue that requirements change rapidly, making a static document outdated quickly.
- Use incremental collection of user requirements through short user stories prioritized by users.

2. **Traditional Approaches**:

- Often require detailed documents, especially for business and dependability requirements.
- More suitable for stable or critical systems where safety and security are paramount.

Target Audience

- The document caters to a diverse set of users, from senior management to software engineers.
- Due to the diversity of users, the document must be a compromise, providing both general overviews and detailed specifications.

Level of Detail

- Varies based on the type of system and the development process.
- Outsourced or critical systems require more detailed specifications.
- In-house, iterative developments may opt for less detailed initial requirements, refining them as the project progresses.

Structure and Content

- Often follows standards like IEEE 1998, which can be adapted to specific uses.
- Should include information about future system evolution to guide designers and maintainers.
- Comprehensive table of contents and document index are essential for complex systems.

Variability

- The content and structure are influenced by the type of software being developed and the development approach.
- For in-house software products, focus is mainly on user requirements and high-level, nonfunctional system requirements.

In summary, the Software Requirements Document is a versatile tool that varies in structure and detail depending on the project's needs. It balances between being comprehensive for developers and testers, and being understandable for stakeholders.

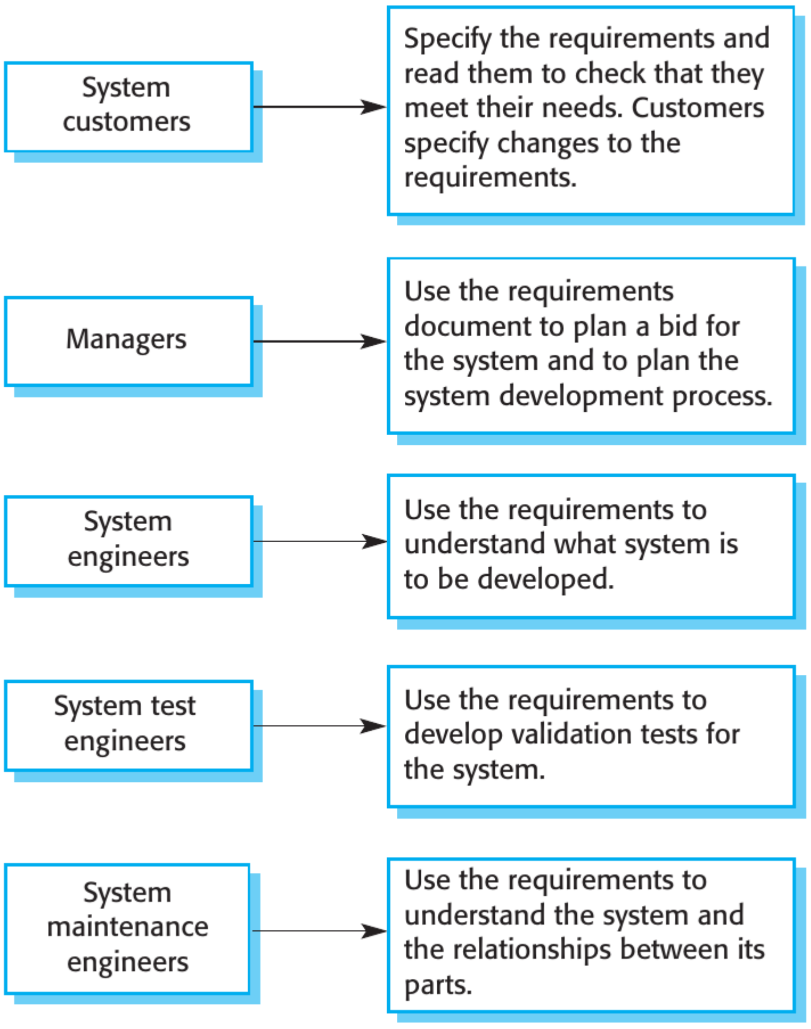
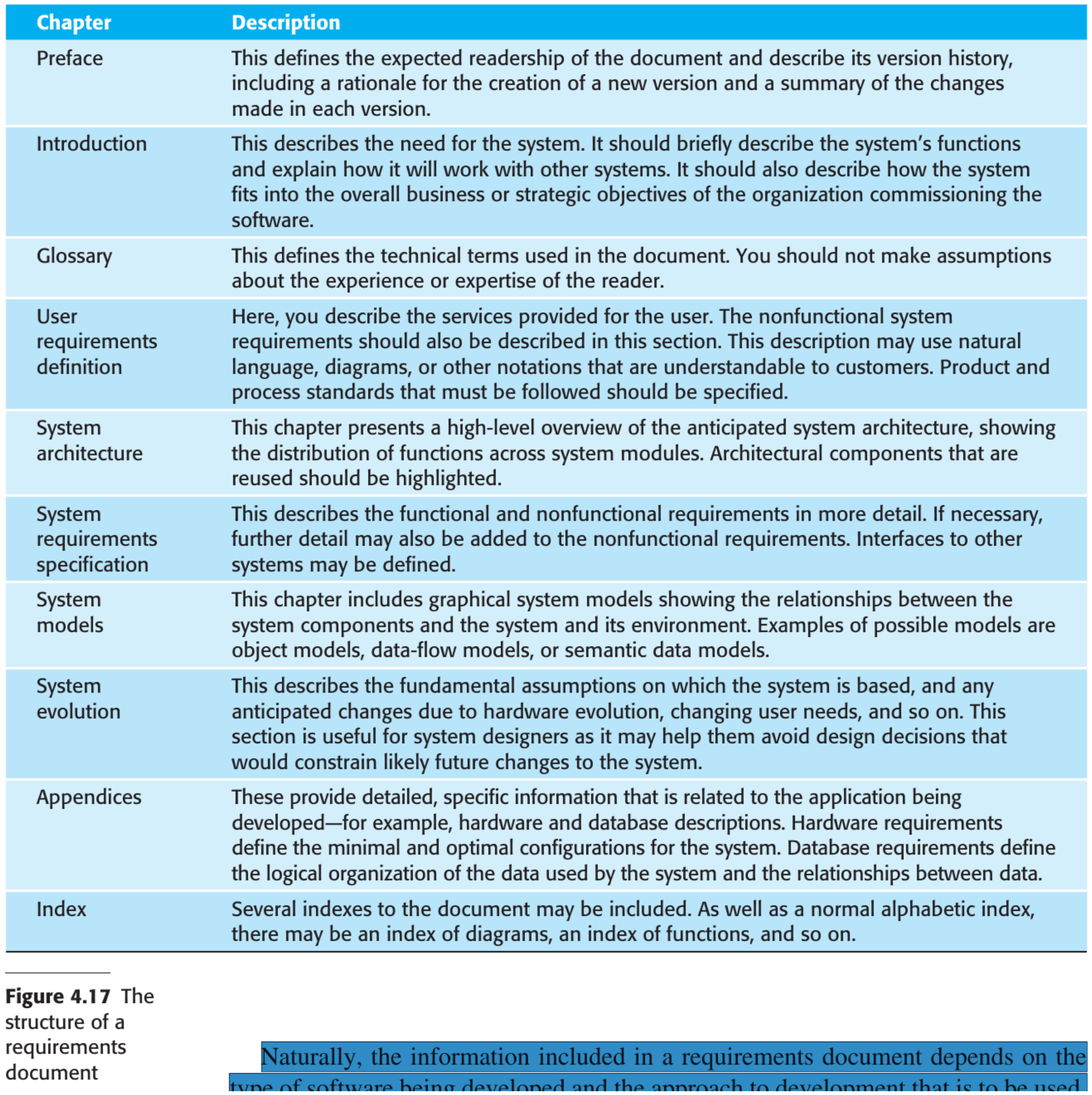

System customers
Specify the requirements and read them to check that they meet their needs. Customers specify changes to the requirements.
Managers
Use the requirements document to plan a bid for the system and to plan the system development process.
System engineers
Use the requirements to understand what system is to be developed.
System test engineers
Use the requirements to develop validation tests for the system.
System maintenance engineers
Use the requirements to understand the system and the relationships between its parts.

Figure 4.16 Users of a requirements document



Chapter	Description
Preface	This defines the expected readership of the document and describe its version history, including a rationale for the creation of a new version and a summary of the changes made in each version.
Introduction	This describes the need for the system. It should briefly describe the system's functions and explain how it will work with other systems. It should also describe how the system fits into the overall business or strategic objectives of the organization commissioning the software.
Glossary	This defines the technical terms used in the document. You should not make assumptions about the experience or expertise of the reader.
User requirements definition	Here, you describe the services provided for the user. The nonfunctional system requirements should also be described in this section. This description may use natural language, diagrams, or other notations that are understandable to customers. Product and process standards that must be followed should be specified.
System architecture	This chapter presents a high-level overview of the anticipated system architecture, showing the distribution of functions across system modules. Architectural components that are reused should be highlighted.
System requirements specification	This describes the functional and nonfunctional requirements in more detail. If necessary, further detail may also be added to the nonfunctional requirements. Interfaces to other systems may be defined.
System models	This chapter includes graphical system models showing the relationships between the system components and the system and its environment. Examples of possible models are object models, data-flow models, or semantic data models.
System evolution	This describes the fundamental assumptions on which the system is based, and any anticipated changes due to hardware evolution, changing user needs, and so on. This section is useful for system designers as it may help them avoid design decisions that would constrain likely future changes to the system.
Appendices	These provide detailed, specific information that is related to the application being developed—for example, hardware and database descriptions. Hardware requirements define the minimal and optimal configurations for the system. Database requirements define the logical organization of the data used by the system and the relationships between data.
Index	Several indexes to the document may be included. As well as a normal alphabetic index, there may be an index of diagrams, an index of functions, and so on.

Figure 4.17 The structure of a requirements document

Naturally, the information included in a requirements document depends on the type of software being developed and the approach to development that is to be used

4.5 Requirements validation

Requirements Validation: Overview

- A critical process aimed at ensuring the requirements define the system the customer truly wants.
- Errors in the requirements document can lead to extensive rework and associated costs.

Importance of Validation

- Cost of fixing requirements errors is usually much higher than fixing design or coding errors.
- Changes to requirements often necessitate changes in design, implementation, and retesting.

Types of Checks

1. **Validity Checks**: Ensure requirements reflect real needs of users, considering possible changes since initial elicitation.
2. **Consistency Checks**: Ensure there are no conflicting or contradictory requirements in the document.
3. **Completeness Checks**: Verify that all functions and constraints intended by the user are defined.
4. **Realism Checks**: Validate that requirements can be implemented within budget and schedule constraints.
5. **Verifiability**: Make sure requirements are written in a way that allows them to be verified through testing.

Validation Techniques

1. **Requirements Reviews**: Systematic analysis by a review team to check for errors and inconsistencies.
2. **Prototyping**: Creation and use of an executable model to gather feedback from end-users and customers.
3. **Test-case Generation**: Developing tests based on requirements to identify issues; integral to test-driven development.

Challenges and Limitations

- Difficult to guarantee that requirements fully meet users' needs.
- Users may struggle to visualize the system and how it fits into their work.
- Not all requirements problems are usually found during validation; further changes are often needed later.

In summary, requirements validation is a complex but critical process that uses various checks and techniques to ensure that the system being developed aligns with what the customer actually wants. Despite its challenges, it is a vital step to minimize future rework and associated costs.

4.6 Requirements change

Requirements Change: Overview

- Requirements for large systems are subject to constant change, often due to the complexity of "wicked" problems that cannot be fully defined.

Reasons for Change

1. **Business and Technical Environment**: Post-installation changes in hardware, interfacing with other systems, business priorities, and new regulations may necessitate adjustments.
2. **Diverse Stakeholders**: Requirements may be imposed by system customers for organizational and budgetary reasons, which may conflict with end-user needs. Post-delivery adjustments may be necessary.
3. **Stakeholder Priorities**: Large systems usually have diverse stakeholders with potentially conflicting requirements. Experience may reveal the need to re-prioritize support for different stakeholders.

Managing Requirements Change

- Formal process needed for making change proposals and linking these to existing requirements, known as "requirements management."
- Should start as soon as a draft version of the requirements document is available.

Agile Development and Requirements Change

- Agile processes are designed to cope with changing requirements.
- Users prioritize changes, and high-priority changes can replace planned features for the next iteration.
- However, this approach can be problematic as users may not be the best to decide cost-effectiveness.

Independent Authority

- An independent authority is often better suited to balance the needs of all stakeholders and decide on the changes to be accepted.

In summary, requirements change is an inevitable aspect of software development, especially for complex systems. Various factors contribute to this, including changes in the business environment, conflicting stakeholder priorities, and the inherent nature of complex problems. Effective management of these changing requirements is crucial, and different approaches like Agile have their own pros and cons. An independent authority can often offer a balanced perspective on what changes should be accepted.

4.6.1 Requirements management planning

Requirements Management Planning: Overview

- The focus is on establishing how an evolving set of requirements will be managed.

Planning Stage Decisions

1. **Requirements Identification**: Each requirement needs a unique identifier for cross-referencing and traceability.
2. **Change Management Process**: A set of activities to assess the impact and cost of changes.
3. **Traceability Policies**: Define the relationships between each requirement and between the requirements and system design, along with how these records are maintained.
4. **Tool Support**: Tools range from specialist requirements management systems to spreadsheets and simple databases.

Tool Support Needs

1. **Requirements Storage**: A secure, managed data store accessible to all stakeholders.
2. **Change Management**: Tools can simplify the change management process by tracking suggested changes and responses.
3. **Traceability Management**: Tools can help discover related requirements, some even using natural language processing techniques for this purpose.

Scale of the System and Tooling

- For small systems, simple tools like shared web documents, spreadsheets, and databases may suffice.
- For larger systems, specialized tools like DOORS are more appropriate for managing a large number of changing requirements.

In summary, requirements management planning involves key decisions on identifying requirements, managing changes, establishing traceability policies, and selecting appropriate tools. The scale of the system often dictates the complexity of the tools needed, with specialized software being more suited for larger, more complex projects.

4.6.1 Requirements change management

Requirements Change Management: Overview

- Change management is crucial after the requirements document has been approved to weigh the benefits and costs of implementing new requirements.
- A formal process ensures consistent treatment of all change proposals and controlled changes to the requirements document.

Principal Stages of Change Management

1. **Problem Analysis and Change Specification**:
   - Begins with an identified requirements problem or a specific change proposal.
   - Validate the problem or change proposal and get feedback from the requestor for further clarification or withdrawal.
2. **Change Analysis and Costing**:
   - Evaluate the impact of the proposed change using traceability information and general system knowledge.
   - Estimate the cost of the change in terms of modifications to the requirements document and possibly to the system design and implementation.
   - Decide whether or not to proceed with the requirements change.
3. **Change Implementation**:
   - Modify the requirements document and, if necessary, the system design and implementation.
   - Aim for a changeable document structure to allow for easy modifications without extensive rewriting.

Emergency Changes

- In cases of urgent new requirements, the temptation to change the system first and update the document later should be resisted.
- Failure to immediately update the requirements document can lead to inconsistencies between the document and the actual system.

In summary, requirements change management is a structured process comprising problem analysis, change analysis and costing, and change implementation. It aims to control and document changes to the system requirements in an organized and consistent manner. Emergency changes are a special case where immediate action may be necessary, but these should be documented as soon as possible to maintain consistency.

Summary

- Requirements for a software system set out what the system should do and define constraints on its operation and implementation.
- Functional requirements are statements of the services that the system must provide or are descriptions of how some computations must be carried out.
- Non-functional requirements often constrain the system being developed and the development process being used. These might be product requirements, organizational requirements, or external requirements. They often relate to the emergent properties of the system and therefore apply to the system as a whole.
- The requirements engineering process includes requirements elicitation, requirements specification, requirements validation, and requirements management.
- Requirements elicitation is an iterative process that can be represented as a spiral of activities—requirements discovery, requirements classification and organization, requirements negotiation, and requirements documentation.
- Requirements specification is the process of formally documenting the user and system requirements and creating a software requirements document.
- The software requirements document is an agreed statement of the system requirements. It should be organized so that both system customers and software developers can use it.
- Requirements validation is the process of checking the requirements for validity, consistency, completeness, realism, and verifiability.
- Business, organizational, and technical changes inevitably lead to changes to the requirements for a software system. Requirements management is the process of managing and controlling these changes.